Letters to the Editor.

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Fossil Buttercups.

It is remarkable, as Prof. Cockerell points out in Nature of January 12, p. 42, that until his discovery of a Miocene buttercup no species of the family Ranunculaceæ should have been recorded among the fossil plants of North America. More especially is this the case because the carpels of Ranunculus are among the commonest fossils found in deposits of Pleistocene and Pliocene age in Britain and the neighbouring parts of the Continent. Among the many lists of fossils determined by my husband and myself from such deposits, in one only, the Pliocene of Bidart (Basses-Pyrénées), is the genus not represented, and in this deposit very few species of any kind were found.

The oldest carpel I have seen is that of an extinct batrachian Ranunculus (*R. gailensis,* E. M. Reid), very thick-walled and globose, from the base of the Pliocene of Pont-de-Gail (Cantal). From the same horizon, but another locality in Cantal, M. Pierre Marty recorded *R. atavorum,* Sap., which he considers nearly related to *R. fluitans*. It is quite probable, though it has not been proved, that carpel and leaf belong to the same species.

In the latest Pliocene of the Cromer Forest-bed, with the exception of two undetermined carpels, all are British species. In the Upper Pliocene of Tegelen (Holland) *R. aquatilis* and *R. repens* are found associated with *R. nodiflorus,* a species of Central Europe and the Orient, and with a single specimen of a peculiar form of *R. sceleratus* found more abundantly at Castle Eden. In the Middle Pliocene of Castle Eden no definite West European species is found, though the form of *R. sceleratus* already mentioned and a peculiar batrachian Ranunculus, both probably extinct, occur associated with two Central European species, *R. nodiflorus* and a varietal form (perhaps extinct) of *R. lateriflorus,* also an extinct species of which the affinity has not been discovered. In the Lower Pliocene of the Dutch-Prussian border the only West European species is *R. nemorosus*; it occurs associated with *R. nodiflorus, R. lateriflorus,* var., and the South European species *R. brutius*. In the lowest Pliocene of Pont-de-Gail one specifically indeterminable carpel and the batrachian *R. gailensis,* already referred to, were found.

Among the hundreds of Pleistocene and Pliocene specimens examined none has shown indications of two seeds, but I have not been able to carry the record of the genus so far back as Prof. Cockerell.

In the work here referred to the carpels were in every case obtained by "washing" the material and sieving away the matrix. Were this method applied to some of the North American Pleistocene and Tertiary deposits I should anticipate that they might yield, not only abundant carpels of Ranunculus, but the fruits and seeds of many other herbaceous plants.

Eleanor M. Reid.

Pinewood, Milford-on-Sea, January 23.

The Accuracy of Tide-predicting Machines.

In the article in Nature for November 24 last appearing under the title "British Research on Tides" there occurs a statement which may, perhaps, leave an erroneous impression with those not familiar with tide-predicting machines. The statement in question —"a test of the accuracy of the tide-predicting machines used by the Admiralty and the India Office has indicated some serious errors in their results, and it is concluded that the labour of reading the curves afforded by the machines, with any pretence to accuracy, is comparable with the labour of direct computation, while the value of the results is greater in the latter case"—although made definitely with reference to particular tide-predicting machines, might, nevertheless, leave the impression that tide-predicting machines in general were subject to "serious errors in their results." It therefore appears of value to discuss briefly the subject of the accuracy of tide-predicting machines and to refer to some tests made with a direct-reading type of tide predictor.

Tide-predicting machines, or tide predictors as they are frequently called, make use of the harmonic tidal constants, and are contrived for the purpose of summing a number of terms of the form $A \cos (at+\alpha)$, in which for each harmonic constant A is the amplitude, a the speed per unit time t, and α the initial phase. For any given port, therefore, the height of the tide at any time is the instantaneous sum of the simple constituent tides represented by the harmonic constants. And in the tide predictor this instantaneous summation is effected by means of a flexible chain which passes alternately over and under a series of pulleys the motion of each of which represents the changes in elevation of a particular simple tide.

The accuracy of a tide predictor is therefore to be measured by the accuracy with which it sums the simple constituent tides represented by the harmonic constants. It is necessary to emphasise this, for not infrequently one meets with the assumption that the accuracy of the tidal predictions tests the accuracy of the tide predictor. Tidal predictions are the product of the tide predictor, and for any given port aim to give in advance the times and heights of high and low water. And the test of the accuracy of these tidal predictions is, obviously, the closeness of agreement with the tides as they actually occur.

It is to be noted, however, that the times and heights of the normal or predictable tide are subject to the disturbing effects of variations in wind, atmospheric pressure, rainfall, and seiche. Hence, altogether apart from any imperfections in the tide predictor or in the harmonic analysis which separates out the simple constituent tides, tidal predictions may differ from the observed times and heights of the tide, due to the disturbing effects just mentioned, the times of occurrence of which cannot be foreseen at the time the tidal predictions are made. It is, therefore, obvious that, while in a measure the accuracy of the tidal predictions tests all the processes entering into their making, it does not strictly test the accuracy of the tide predictor.

Tide predictors are of two types, which we may denominate respectively as curve-tracing machines and direct-reading machines. In the former there is traced, to a suitable scale on a sheet of paper, a curve of the predicted tide from which the height of the tide at any given time or the times and heights of high and low water may be scaled. In the direct-reading tide predictor the height of the tide at any time, and also the times and heights of high and low water, are indicated on dials from which they are read off directly.

It is obvious that the prediction of tides can be carried out more rapidly with a direct-reading tide predictor than with the curve-tracing type, for reading figures from two or three dials is less time-consuming than scaling these same values from a curve. But

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even apart from its greater economy in time, the direct-reading machine has a still further advantage in that it is possible to secure more accurate results than with the use of the curve-tracing type. The dials on the direct-reading tide predictor are graduated to single minutes and to single tenths of a foot; it is, therefore, not difficult to estimate to within half a minute or five hundredths of a foot. To estimate as closely from a curve drawn to a moderate time-and-height scale is well-nigh impossible.

Since the tide predictor sums a number of continuous functions, it cannot be made to give the exact results of an adding or a multiplying machine. And because of the large number of moving parts that enter into the construction of a tide predictor, we cannot hope to secure the accuracy that may be obtained with a planimeter. In fact, the errors of the tide predictor may be ascribed almost wholly to the varying tensions on the numerous moving parts, but it appears that these errors should not be large enough to be serious.

In 1910 the U.S. Coast and Geodetic Survey put into operation a direct-reading tide predictor which had been constructed in its instrument division. Prior to the use of this machine for the prediction of tides for the annual tide tables it was carefully tested, one of the tests consisting in the comparison of the hourly heights of the tide as given by the machine and as computed analytically "by hand." The machine was set with 30 components for Hong Kong, China, January 1, 1912, and run through to December 31. For that day hourly heights of the tide were read off for the entire twenty-four hours.

At the beginning of this year, after it had been in use about twelve years, the machine was again set for Hong Kong, January 1, 1912, and run through to December 31, and the hourly heights read off. December 31 was chosen so that all errors due to the incommensurability of the speeds of the various components might accumulate. The table below shows the differences between the computed and the predicted heights:—

Hourly Heights of Tide, Hong Kong, China, December 31, 1912.

Hour	Predicted in 1910. Feet.	Predicted in 1922. Feet.	Computed. Feet.	Differences 1910. Feet.	Differences 1922. Feet.
0	4·28	4·30	4·32	−0·04	−0·02
1	4·65	4·67	4·68	−0·03	−0·01
2	4·78	4·78	4·80	−0·02	−0·02
3	4·60	4·61	4·59	+0·01	+0·02
4	4·07	4·08	4·05	+0·02	+0·03
5	3·27	3·27	3·22	+0·05	+0·05
6	2·32	2·32	2·28	+0·04	+0·04
7	1·42	1·42	1·37	+0·05	+0·05
8	0·70	0·70	0·66	+0·04	+0·04
9	0·31	0·31	0·27	+0·04	+0·04
10	0·34	0·33	0·33	+0·01	0·00
11	0·76	0·78	0·81	−0·05	−0·03
12	1·51	1·52	1·56	−0·05	−0·04
13	2·31	2·32	2·37	−0·06	−0·05
14	3·00	3·01	3·06	−0·06	−0·05
15	3·48	3·48	3·53	−0·05	−0·05
16	3·70	3·68	3·73	−0·03	−0·05
17	3·64	3·63	3·66	−0·02	−0·03
18	3·38	3·38	3·40	−0·02	−0·02
19	3·04	3·06	3·07	−0·03	−0·01
20	2·73	2·74	2·75	−0·02	−0·01
21	2·50	2·52	2·51	−0·01	+0·01
22	2·46	2·47	2·47	−0·01	0·00
23	2·64	2·66	2·67	−0·03	−0·01

It is to be noted that the height-scale on the tide predictor is graduated to tenths, so that the hundredths were estimated. The differences between the heights as predicted and as computed are relatively small, in no case exceeding 0·06 ft. It is also interesting to note the close agreement between the predictions made in 1910 and those in 1922, these predictions being made not only twelve years apart, but also by different persons. It is only proper to add that these predictions were undoubtedly carried out with more than ordinary care, owing to the psychological effect of the knowledge that a test was involved. Furthermore, it must be stated that with a single-component tide the accuracy attained was not so gratifying as in the example given above, the reason being that with a number of components there are compensating tensions of the moving parts, while with a single component there are no such compensations. It is to be borne in mind, however, that in the prediction of tides there is always a considerable number of components involved.

It would be unfortunate if the impression that tide predictors are subject to serious errors gained currency, for, apart from the use of such machines for the prediction of tides for the tide-tables, there are numerous tidal problems involving time-consuming computations which may be very easily made with the tide predictor. In the elimination of the effects of short-period tides on daily mean sea-level, in the computation of the changes in sea-level due to tides of long period, in the elimination from the observed tide of the tide due to a number of constituents, and in similar problems, the tide predictor should very materially lessen the laborious computations involved.

H. A. MARMER.

U.S. Coast and Geodetic Survey, Washington,
D.C., January 5.

THE errors found in the British tide-predicting machines referred to in the article were more serious than those described by Mr. Marmer. The machines were of the curve-tracing type, and therefore inevitably less accurate (with the time and height scales ordinarily used) than direct-reading machines; they had zero errors, and also diminished the apparent range of the tide. The direct-reading machine used by Mr. Marmer is both more accurate and quicker in use; for many purposes, though perhaps not for all, such a machine is a valuable substitute for numerical computation.

THE WRITER OF THE ARTICLE.

The Oxidation of Ammonia.

THE following details of the early history of the oxidation of ammonia, a process which became of great importance during the war, do not appear generally to be known, and may be of interest. The first clear statement of the oxidation of ammonia which I have seen is contained in a paper by the Rev. Isaac Milner, B.D., F.R.S., president of Queens' College, Cambridge, published in the Philosophical Transactions for 1789 (vol. 79, pt. 2, pp. 300–13), and republished in Crell's *Annalen* (1795, pt. 1, pp. 550–62). The title of the English paper is "On the Production of Nitrous Acid and Nitrous Air," and the German paper is a translation, in which "nitrous acid" is rendered "Saltpetersäure" and "nitrous air" (*i.e.* nitric oxide, NO) "Saltpeterluft."

Milner remarks that, although the relation between nitrous acid and the volatile alkali was known, there was no known case in which the latter was used in the production of nitrous acid or nitrous gas. In

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